

APPLICATION NO. 10/772,597

INVENTION: Decisioning rules for turbo and convolutional decoding

INVENTORS: Urbain A. von der Embse

Clean version of how the CLAIMS will read

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CLAIMS

WHAT IS CLAIMED IS:

10 Claim 1. (currently amended) A method for performing a new turbo decoding algorithm using a-posteriori probability $p(s, s' | y)$ in equations (13) for defining the maximum a-posteriori probability MAP, comprising::
using a new statistical definition of the MAP logarithm
15 likelihood ratio $L(d(k) | y)$ in equations (18)

$$L(d(k) | y) = \ln [\sum_{(s, s' | d(k)=1)} p(s, s' | y)] - \ln [\sum_{(s, s' | d(k)=0)} p(s, s' | y)]$$

20 equal to the natural logarithm of the ratio of the a-posteriori probability $p(s, s' | y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=1$ to the $p(s, s' | y)$ summed over all state transitions $s' \rightarrow s$ corresponding to the transmitted data $d(k)=0$,
25 using a factorization of the a-posteriori probability $p(s, s' | y)$ in equations 13 into the product of the a-posteriori probabilities

$$p(s, s' | y) = p(s | s', y(k)) p(s | y(j > k)) p(s' | y(j < k));$$

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using a turbo decoding forward recursion equation

$$p(s | y(j < k), y(k)) = \sum_{\text{all } s'} p(s | s', y(k)) p(s' | y(j < k))$$

for evaluating said a-posteriori probability $p(s'|y(j<k))$ in equations 14 using $p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path $s' \rightarrow s$ to the new state s at k from the previous state s' at $k-1$ and given the observed symbol $y(k)$ to update these recursions for the assumed value of the user data bits $d(k)$ equivalent to the transmitted symbol $x(k)$ which is the modulated symbol corresponding to $d(k)$,

10 using a turbo decoding backward recursion equation

$$p(s'|y(j>k-1)) = \sum_{\text{all } s} p(s|y(j>k))p(s'|s,y(k))$$

for evaluating the a-posterior probability $p(s|y(j>k))$ in equations 15 using said $p(s'|s,y(k)) = p(s|s',y(k))$ as the state transition a-posteriori probability of the trellis transition path evaluating the natural logarithm of the state transition a-posteriori probability $p(s|s',y(k)) = p(s'|s,y(k))$ equal to the new decisioning metric DX in equations 11, 16, defined by equation

$$\begin{aligned} \ln[p(s|s',y(k))] &= \ln[p(s'|s,y(k))] \\ &= \text{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \ln[p(d(k))] \\ &= DX \end{aligned}$$

25 wherein p is the natural logarithm \ln of p , x^* is the complex conjugate of x , and $\ln[\sigma]$ is the natural logarithm of $[\sigma]$,

whereby said new state transition probabilities in said MAP 30 equations use said DX linear in $y(k)$ in place of the current use of the maximum likelihood decisioning metric $DM = [-|y(k) - x(k)|^2/2\sigma^2]$ which is a quadratic function of $y(k)$,

whereby said MAP turbo decoding algorithms provide some of the performance improvements demonstrated in FIG. 5,6 using said DX, and.

whereby this new a-posteriori mathematical framework enables 5 said MAP turbo decoding algorithms to be restructured and to determine the intrinsic information as a function of said DX linear in said $y(k)$.

10 Claim 2. (currently amended) A method for performing a new convolutional decoding algorithm using the MAP a-posteriori probability $p(s,s'|y)$ in equations 13, comprising::

15 using a new maximum a-posteriori principle which maximizes the a-posteriori probability $p(x|y)$ of the transmitted symbol x given the received symbol y to replace the current maximum likelihood principle which maximizes the likelihood probability $p(y|x)$ of y given x for deriving the forward and the backward recursive equations to implement convolutional decoding,

20 using the factorization of the a-posteriori probability $p(s,s'|y)$ in equations 13 into the product of said a-posteriori probabilities $p(s'|y(j < k))$, $p(s|s',y(k))$, $p(s|y(j > k))$ to identify the convolutional decoding forward state metric $a_{k-1}(s')$, backward state metric $b_k(s)$, and state 25 transition metric $p_k(s|s')$ as the a-posteriori probability factors

$$p_k(s|s') = p(s|s',y(k))$$

$$b_k(s) = p(s|y(j > k))$$

$$a_{k-1}(s') = p(s'|y(j < k)),$$

30

using a convolutional decoding forward recursion equation in equations 14 for evaluating said a-posteriori probability $a_k(s) = p(s|y(j < k), y(k))$ using said $p_k(s|s') = p(s|s',y(k))$ as 35 said state transition probability of the trellis transition

path $s' \rightarrow s$ to the new state s at k from the previous state s' at $k-1$,
using a convolutional decoding backward recursion equation in
equations 15 for evaluating said a-posteriori
5 probability $b_k(s) = p(s|y(j>k))$ using said
 $p_k(s'|s) = p(s'|s, y(k))$ as said state transition probability
of the trellis transition path $s \rightarrow s'$ to the new state s' at
 $k-1$ from the previous state s at k ,
evaluating the natural logarithm of said state transition
10 a-posteriori probabilities

$$\begin{aligned} \ln[p_k(s'|s)] &= \ln[p(s'|s, y(k))] \\ &= \ln[p(s|s', y(k))] \\ &= \ln[p_k(s|s')] \\ &= DX \end{aligned}$$

15 equal to the new decisioning metric DX in equations
16, and
implementing said convolutional decoding algorithms to
20 obtain some of the performance improvements demonstrated in
FIG. 5,6 using said DX .

25 **Claim 3.** (currently amended) Wherein in **claim 2** a method
for implementing the new convolutional decoding recursive
equations, said method comprising:
30 implementing in equations 14 a forward recursion equation
for evaluating the natural logarithm, \underline{a}_k , of a_k using the
natural logarithm of the state transition a-posteriori
probability $p_k = \ln[p(s|s', y(k))]$ of the trellis transition
path $s' \rightarrow s$ to the new state s at k from the previous state
 s' at $k-1$, which is equation

$$\underline{a}_k(s) = \max_{s'} [\underline{a}_{k-1}(s') + p_k(s|s')]$$

$$\begin{aligned}
 &= \max_{s'} [\underline{a}_{k-1}(s') + DX(s|s')] \\
 &= \max_{s'} [\underline{a}_{k-1}(s') + \text{Re}[y(k)x^*(k)]/\sigma^2 - |x(k)|^2/2\sigma^2 + \underline{p}(d(k))]
 \end{aligned}$$

wherein said $DX(s|s') = \underline{p}_k(s|s') = \underline{p}_k(s'|s) = DX(s'|s) = DX$ is the
5 new decisioning metric, and

implementing in equations 15 a backward recursion equation
10 for evaluating the natural logarithm, \underline{b}_k . of b_k using
the natural logarithm of said state transition a-posteriori
probability $\underline{p}_k = \ln[p(s'|s, y(k))] = \ln[p(s|s', y(k))]$ of the
trellis transition path $s \rightarrow s'$ to the new state s' at $k-1$ and
is equation

$$\underline{b}_{k-1}(s') = \max_s [\underline{b}_k(s) + DX(s'|s)].$$

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